Biotechnology and Aquaculture: Meeting Growing Seafood Demand Sustainably

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The Philippines have a total area of 2,200,000 km² total length of 36,289 km coastline.

Fishing is one of the major sources of livelihood in the country where there were about 1.99 million fishers and 0.35 million fish farmers in 2019.

11th in aquaculture production in 2019.

1.50 million MT in Seaweeds Production (2021) – 4th largest producer of aquatic plants.

Source: 2021 Philippine Fisheries Profile
- 2.19 million fisherfolks engaged in fishing activities
- USD 1.89 billion aquaculture production including fish, crustaceans, and mollusks total value
- 40 kg/year average per capita Filipino fish consumption

### Total fishery production of the Philippines by quantity (MT)

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<tbody>
<tr>
<td>Total</td>
<td>4,398,589</td>
<td>4,413,129</td>
<td>4,613,074</td>
<td>4,312,663</td>
<td>4,350,761</td>
<td>4,645,871</td>
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<td>Capture Fisheries</td>
<td>2,075,758</td>
<td>2,054,891</td>
<td>2,308,709</td>
<td>2,074,876</td>
<td>2,149,847</td>
<td>2,297,712</td>
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<td>Marine Capture</td>
<td>1,927,343</td>
<td>1,900,210</td>
<td>2,145,735</td>
<td>1,911,006</td>
<td>1,994,338</td>
<td>2,094,346</td>
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<tr>
<td>Inland Capture</td>
<td>148,415</td>
<td>154,681</td>
<td>162,974</td>
<td>163,870</td>
<td>155,509</td>
<td>203,366</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>2,322,831</td>
<td>2,358,238</td>
<td>2,304,365</td>
<td>2,237,787</td>
<td>2,200,914</td>
<td>2,348,159</td>
</tr>
</tbody>
</table>

Source: Fishery Statistical Bulletin of Southeast Asia 2020

Source: 2021 Philippine Fisheries Profile
FAO United Nations 2020
Aquaculture is practiced in freshwater, brackish and marine water using a variety of species.

Top 15 aquaculture-producing countries worldwide and within the top 5 in Southeast Asia.

Source: 2021 Philippine Fisheries Profile
✔ Aquaculture the country’s main source of fish

✔ Tilapia, milkfish and shrimp common farmed species

✔ Recorded decreasing over the years

✔ Due to large exploitation
Challenges in Aquaculture

✔ Emerging diseases and trans-boundary movement of aquatic animal diseases

✔ Resiliency of the fisheries industry from climate change, calamities, economic shocks, and the pandemic

✔ Decrease of production over the years
BIOTECH IN FISHERIES

TRADITIONAL

- Tissue culture (micropropagation)
- Bio-fertilizers
- Bio-control agents
- Vaccines, Probiotic
- Patis, Bagoong, etc.

MODERN

- Marker technologies
- Genomics and other "-omics" technologies
- CRISPR technology
- Genetic engineering
- Transgenic Glow Fish
APPLICATION OF BIOTECHNOLOGY IN AQUACULTURE

**Biotechnological Methods**

- Fish Breeding
- Disease and health management
- Germ cell transplantation
- Feed and nutrition biotechnology
- Embryonic Stem Cell Technology
- Genome Mapping

**Improved outcomes**

- Improved growth rate and productivity
- Increased resistance to pathogens
- Improved broodstock quality and control reproduction
- Produce new/better products
BIOTECHNOLOGY TOOLS IN FISHERIES

- Fish Breeding
  - New breeding Techniques
  - Sex Control and Transgenesis
- Aquaculture Nutrition
- Fish Health Management
- Molecular Biology
- Cryopreservation
Fish Breeding

- Induced breeding - Gonadotropin releasing hormone (GnRH).
- GnRH analogue profusely used now in fish breeding and marked commercially under the name of “Ovaprim”.
Natural and artificial selection

- **Natural Selection**: The process by which favourable traits that are inheritable become more and more common in a species when individuals are allowed to breed naturally.
- **Artificial Selection**: The controlled breeding of a species to encourage certain traits over others

- **Artificial sexual hybridization** - hybridization among distantly related fish species

- **Nuclear transplantation** - to transfer a diploid nucleus into an enucleated egg for investigating the roles of nucleus in initiating embryonic development

- **Gene transfer** - transfer of genetic materials
New breeding techniques

- Transgenic Salmon
  
- CRISPR technology

[Link to article about genetically modified salmon](https://thefishsite.com/articles/genetically-modified-salmon-changing-the-future)
Sex Control and Transgenesis

**Sex Control**
- The process of sex differentiation in teleost is protracted and labile rendering the hormonal induction of sex reversal possible in gonochoristic and hermaphroditic species.

**Transgenesis**
- Opportunity for modifying or improving the genetic traits of commercially important fishes, mollusks and crustaceans for aquaculture.
Aquaculture Nutrition

The use of biotechnologically improved products and appropriate use of locally available feed ingredients in semi-intensive aquaculture is still needed.
Fish Health Management

Molecular diagnostic methods, use of vaccines and immuno-stimulants are gaining popularity for improving the disease resistance in fish and shellfish species.
Genetic identification of aquaculture stocks is a fundamental requirement in any culture programme.
Cryopreservation

The technology of cryopreservation of fish spermatozoa (milt) has been adopted for fisheries industry.
GROWTH ENHANCEMENT

Extraordinary salmon growth

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TRANSGENIC

Transgenic growth enhanced-Tilapia

Source: Maclean and Laight (2000)
Aquaculture biotechnology in the Philippines

YY tilapia
Improved EXCEL tilapia
Oreochromis spp. Red Tilapia

Oreochromis hornorum Hybrid
GenoMar Supreme Tilapia

Source: Tilapia culture: the basics / Maria Rowena R. Romana-Eguia, Ruel V. Eguia, Rolando V. Pakingking, Jr. -- Tigbauan, Iloilo, Philippines: Aquaculture Dept., Southeast Asian Fisheries Development Center, 2020
Aquaculture biotechnology in the Philippines

✔ Emerging aquatic disease diagnostics
✔ Protocol development in molecular genetics
✔ Reproductive biotechnology
✔ Natural products development
✔ Species conservation initiatives
✔ Vaccine development
Induce Spawning Technology

What is it?

- Regulation of environmental condition or by introduction of hormones to stimulate factors that trigger reproduction.

- Promotes ripening of gonads and timely release of sperms and eggs
Induce Spawning Technology

✔ Ease fishing pressure from the wild and aid in species conservation and proper management.

✔ Increase productivity, provide fisherfolks an alternative source of livelihood, and increase income.
Induce Spawning Technology
Induce Spawning Technology

Why is it essential to aquaculture?

✔ The technique is very simple and does not need too much technical assistance or knowledge.
✔ Removes uncertainties in breeder spawning.
✔ Targeted/scheduled spawning is possible and can produce fry outside spawning season for hatchery and/or grow-out.
✔ Can provide pure spawn on fish under cultivation.
✔ Offers more controlled hatchery or aquaculture operations
The Spawning Process in Fish

NATURAL SPAWNING PROCESS

Hypothalamus

Pituitary Gland

Gonadotropin Hormones (GtH)
- FSH
- LH

Sex steroid hormones
- Progesterone
- Testosterone

Ovulation/Spermiation
The Science Behind Induced Spawning

**INDUCED SPAWNING**

The objective is to bypass natural biological processes to speed up (or induce) spawning in fish

- Hypothalamus
  - (GnRH)
- Pituitary Gland
- Gonadotropin Hormones (GtH)
  - FSH
  - LH
- Sex steroid hormones
  - Progesterone
  - Testosterone
- Ovulation/Spermiation
Induce Spawning Technology

**INDUCED SPAWNING**

- Use of inducing agents
- Manipulate environmental conditions in captivity

**Hypothalamus**

(GnRH)

**Pituitary Gland**

- **Gonadotropin Hormones (GtH)**
  - FSH
  - LH

**Sex steroid hormones**

- Progesterone
- Testosterone

**Ovulation/Spermiation**
Biotechnology offers the aquaculture industry a powerful set of tools to meet the increasing demand for seafood sustainably and food security.

On going research and innovation drive progress and offer solutions to complex challenges (disease management, resilient, sustainability, and resource optimization).

Extend partnership and collaborations.
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